

Space Weather Technical Forecast

Issued on Sunday, 01 January 2023 at 01:17 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of M-flares throughout. Increasing Chance of Active High Energy Electron Fluence. Possible glancing blow from a CME late in the period.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with frequent C-class flares, the most notable a C9.1 at 31/2148 UTC from AR3180. There are currently five numbered active regions on the visible disc, with AR3176 and AR3180 currently the most magnetically complex, as AR3180 is likely to be next classified as a beta-gamma, the same as AR3176. AR3176 (Eao/beta-gamma) remains the largest region on the disc, but AR3179 (Dao/beta) is not far behind in size. All regions, apart for the small and simple AR3173, have contributed to the C-class flares through the period. At least one CME appears to have been generated by the various C-class flares. Once coronagraph imagery becomes available analysis will be undertaken to determine if any are likely to be Earth directed.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE and DSCOVR were indicative of coronal hole connection, rising rather erratically from around 520-550km/s to become occasionally strong later in the day, peaking at 670km/s at 31/1938 UTC. The density was near average then decreased to below average level. Total Interplanetary Magnetic Field (IMF), Bt, was predominantly Weak, but briefly peaked at Moderate levels reaching 8nT at 31/0143 UTC. The north-south component, Bz, was often negative and fluctuated between +/-6 nT. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Unsettled to Active (Kp 2-4).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) started the period at Background to Moderate levels, but then increased to Moderate to High levels, with a peak of 2.11e3pfu at 31/1535 UTC. The 24-hour integrated electron fluence remained below the Active threshold on a gradually declining trend. The observed fluence at 01/0000 UTC was 6.22e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with an ongoing daily chance of M-flares. There is a slight chance of X-class flares.

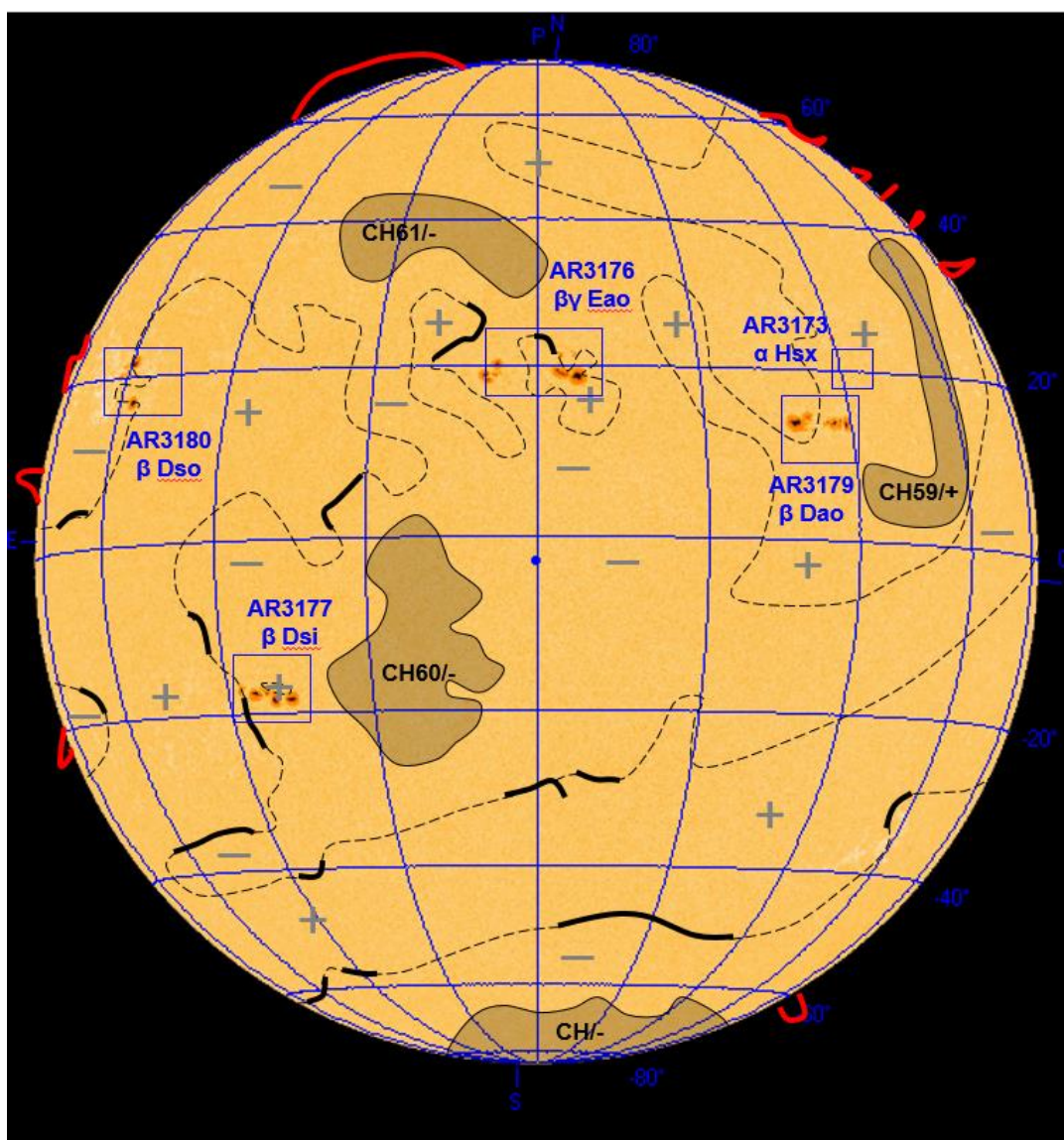
Solar Wind / Geomagnetic Activity: A coronal mass ejection (CME) which was observed in coronagraph imagery, associated with the M1 flare at 30/1528 UTC from AR3176, has been analysed and shows a possible glancing blow at Earth either late on the 3rd Jan (Day 3) or early on the 4th Jan (Day 4). No other Earth directed CMEs are currently expected. The ongoing coronal hole influence is expected to continue today (New Year's Day) then gradually decline through days 2 and 3 (2nd and 3rd Jan). A further coronal hole enhancement is expected later day 4 (4th Jan).

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The resulting geomagnetic activity is expected to be predominantly Quiet to Unsettled (Kp 1-3) but with isolated Active (Kp 4) intervals likely, especially at first today, then from late day 3 onwards.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at Background levels throughout but with a chance of rising alongside any notable flares, giving a very slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) observed by GOES-16 is likely to be Moderate to High levels, with a probable upward trend over the next couple of days. The associated 24 hour fluence will then respond, with an increasing chance of approaching/exceeding the Active ($1e8$ integrated pfu) from late tomorrow (2nd Jan) onwards.

Figure 1. Solar Analysis Valid 31/1945 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - γ - δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

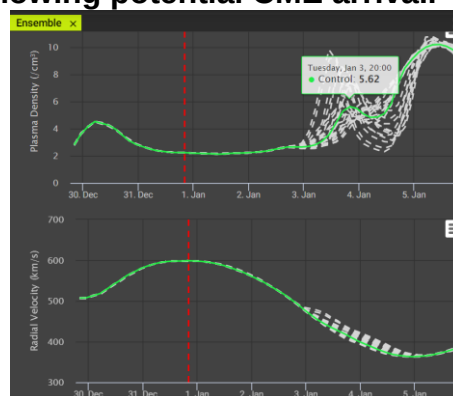
A coronal mass ejection (CME) observed in coronagraph imagery associated with the M1 flare at 30/1528 UTC from AR3176, has been analysed. The data suggests a possible glancing blow from the CME at Earth either late on the 3rd Jan (Day 3) or early on the 4th Jan (Day 4). However, this a low confidence forecast due to the limited (gaps) data available in the coronagraph imagery. Otherwise, no other Earth directed CMEs are currently expected. Solar winds are currently elevated, occasionally reaching strong levels, due to the ongoing connection with CH59/+. The coronal hole influence is expected to continue today (New Year's Day) then gradually decline through days 2 and 3 (2nd and 3rd Jan). A further coronal hole enhancement is expected later day 4 (4th Jan), from a connection to CH61/-. The resulting geomagnetic activity is expected to be predominantly Quiet to Unsettled (Kp 1-3) but with isolated Active (Kp 4) intervals likely, especially at first today, then from late day 3 onwards.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	5	20	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/0141	Partial	M1 flare at 30/1528 UTC	AR3176	390	03/2000 UTC	Low confidence. Limited shock expected.

Figure 2: Enlil ensemble showing potential CME arrival.



Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the past 24 hours, with frequent C-class flares, the largest a C9.1 at 31/2148 UTC from AR3180.

AR3173 remains small, weak and stable. AR3176 and AR3180 are competing for the position of being the most magnetically complex region on the disc, with both beta-gamma classifications. However, AR3176 remains the largest region on the visible disc, and has recently been stable with no significant change in spot number or area. AR3177 in the southeast hasn't shown any changes since previous analysis. AR3179 remains the second largest region, but has also been stable.

Through the forecast period new regions, or returning regions, are expected to rotate onto the visible disc and so the forecast probabilities of significant flares is likely to increase.

Solar Activity is expected to be Low to Moderate with an ongoing chance of M-flares, and a slight chance of X-flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at Background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	10	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) observed by GOES-16 is likely to be Moderate to High levels, with an expected upward trend over the next couple of days due to the ongoing influence of CH59. Later in the period, if significant geomagnetic activity occurs due to a possible CME arrival and also the arrival of the next HSS, so the high energy electron flux may rapidly decrease to Background to Moderate levels.

The associated 24 hour fluence is therefore likely to show an upward trend, leading to an increasing chance of approaching/exceeding the Active ($1\text{e}8$ integrated pfu) from late tomorrow (2nd Jan) onwards. However, late in the period a decreasing trend may develop.

The REFM is currently giving poor guidance, with observed values noticeably lower than the forecast values. However, the increasing upward trend in the fluence is considered reasonable guidance.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	40	50	60	60
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 3: Met Office REFM model.

